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# Negotiating causal implicatures

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## Abstract

In this paper we motivate and describe a dialogue manager which is able to infer and negotiate causal implicatures. A causal implicature is a type of Gricean relation implicature, and the ability to infer them is crucial in situated dialogue. Because situated dialogue interleaves conversational acts and physical acts, the dialogue manager needs to have a grasp on causal implicatures in order not only to decide what physical acts to do next but also to generate causally-aware clarifications.

## 1 Introduction

In conversation, an *important* part of the content conveyed is not explicitly said, rather it is *implicated*. However, Grice (1975)'s classic concept of *conversational implicature* (CI) is far from fully understood. Traditionally CIs have been classified using the Gricean maxims: there are *relation CIs* (also known as relevance CIs), *quantity CIs*, *quality CIs* and *manner CIs*. In formal pragmatics, the most studied CIs are quantity CIs, probably because they are the ones most obviously amenable to theoretical analysis; see (Geurts, in press) for a survey of the state of the art. Far less studied (and traditionally regarded as somewhat obscure) are relation CIs. Obscure perhaps, but crucial: it has been argued that they subsume all other types of CIs (Wilson and Sperber, 2004). This paper is a first step towards their formalization.

We shall analyze a kind of CI that we call *causal CIs*. Causal CIs are relation CIs as defined by Grice (1975) where the crucial relation is *task domain causality*. Consider the following example:

Mary: *The chest is locked, the crown is inside*

Bill: *Give me the crown*

Bill causally implicated: *Unlock the chest*

In order to carry out the task action required by Bill (to give him the crown) it is necessary to unlock the chest. Hence we say that Bill is implicating, by trading on the domain causal relations (after all, the contents of a chest are not accessible unless the chest is unlocked) that Mary is to unlock the chest. Now, once Mary has inferred the causal CI, she may accept this inference silently or negotiate it. Mary might decide to silently accept it because she knows how to get the key; in this case we will say that Mary constructed an *internal bridge* from the current task situation (that is, the crown being inside the locked chest) to the proposal made by Bill (giving him the crown). If Mary decides she has insufficient information to construct the internal bridge (maybe she has no key, or sees that the lock is rusty) she may start a sub-dialogue that we will call an *external bridge*; she might say, for example: *But how can I unlock the chest?* The *internal process of bridging* is what in the literature has been called accommodation (Lewis, 1979) or bridging (Clark, 1975). The *external processes of bridging* constitutes a large part of what we call conversation.

This paper presents a dialogue system (called Frolog) which infers and negotiates *causal CIs* in the context of situated task-oriented dialogue; the framework is intended as a proof-of-concept of the ideas just sketched. We proceed as follows. In Section 2, we motivate the study of causal CIs in dialogue. In Section 3 we present Frolog's dialogue manager which infers causal CIs in situated dialogue. And in Section 4 we illustrate how the negotiation (external bridging) of causal CIs incrementally grounds a pragmatic goal proposed by one of the dialogue participants. Section 5 concludes the paper.

## 2 Causal implicatures and dialogue

The motivation for our work is both theoretical and practical. On the theoretical side, we believe

that it is crucial to explore CIs in the setting of naturally occurring dialogues. Strangely enough (after all, Grice did call them *conversational implicatures*) this view appears to be novel, perhaps even controversial. In the formal pragmatics literature, CIs are often simply viewed as inferences drawn by a hearer on the basis of a speaker’s utterance, contextual information, and the Gricean maxims. We find this perspective too static. CIs (especially relations CIs) are better viewed as intrinsically *interactional* inferences that arise from the dynamics of conversation. As conversations progress, speakers and hearers switch roles: meaning are negotiated and inference becomes bidirectional (Thomason et al., 2006). Moreover, even within a single turn, hearers are not restricted to simply drawing (or failing to draw) “the” CI: in fact, choosing between internal and external bridging is better viewed as part of the process of *negotiating what the CI at stake actually is*. We believe that interactive perspectives will be necessary to extend the theory of CIs beyond the relatively narrow domain of quantity CIs. We also believe that the dialog-centered approach we advocate may have practical consequences. In particular, modeling the *external process of bridging* is a step towards having a pragmatically incremental dialogue manager in the spirit of that sketched in (Buß and Schlangen, 2010).

This is a broad goal, in this paper we focus on clausal implicatures. This restriction gives us an *empirical* handle of CIs. It is not controversial that (in non-conversational activities) the causal relations between acts define the expectations of the interaction. But also in conversational activities situated in a physical task causal relations guide the interaction; we did an empirical study on such a kind of corpus (Benotti, 2009) and we found that, in this corpus, most CIs for which there is evidence (because they are made explicit in a clarification request) can be explained in terms of causal relations. For our empirical study, we annotated and classified the clarification requests (CRs) that appear in the SCARE corpus (Stoia et al., 2008).

### 3 Inferring causal implicatures

In order to model the causal CIs that we observed in the SCARE corpus, and to experiment with different strategies for negotiating these CIs, we designed a system that mimics the instruction giving setup of the SCARE corpus. In our setup, the DF

is a dialogue system that we will call *Frolog*. The human participant that plays the role of the DG we will call “the player”.

In a nutshell, *Frolog* uses an off-the-shelf planner to compute causal implicatures. That is, it uses classical planning (a well explored and computationally efficient AI technique) to fill out the micro-structure of discourse (the bridging information required in the next step).<sup>1</sup> We do so using the planner BLACKBOX (Kautz and Selman, 1999). Like all classical planners, BLACKBOX takes three inputs: the initial state, the goal, and the available actions. The question of what these three elements should be raises a number of issues.

In *Frolog*, two types of information are registered: complete and accurate information about the game world in the *world KB* and a representation of the common ground in the *interaction KB*. Which of these should be used in the initial state? In fact, we need both: we infer the actions intended by the player using the information in the interaction KB but we have to verify this sequence of actions on the world KB to check if it can actually be executed.

Let us now define what the goal of the planning problem should be. *Frolog* should act to make the preconditions of the action true with one restriction. The restriction is that it must be possible for *Frolog* to manipulate these preconditions. However, we don’t need to worry about this restriction because the planner should take care of which propositions are manipulable by *Frolog* and which are not, given the current state. So we can just define the goal as the conjunction of all the preconditions of the command uttered by the player.

To complete the picture, the actions available to the planner are all the actions in the game action database. This means that we are assuming that all the actions that can be executed, are mutually known to *Frolog* and the player.

In order to be able to perform bridging to the mutual information it must be mutually known what the preconditions and the effects of the actions involved are. The assumption that the player and *Frolog* know the exact specification of all the actions that can be executed in the game world is

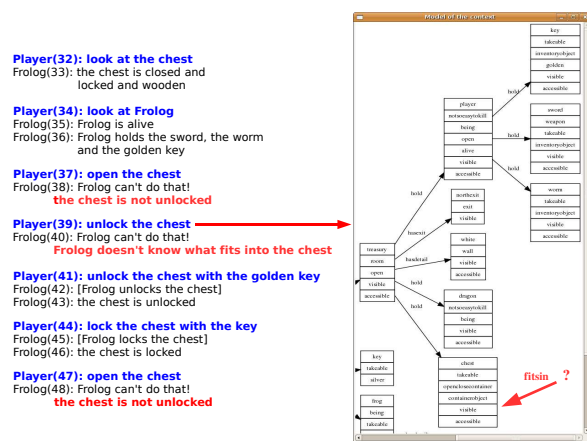
<sup>1</sup>Thus the work reported here is very different from the traditional work of (Perrault and Allen, 1980; Allen and Allen, 1994): classic papers in the plan-based tradition use *plan recognition* (a more computationally expensive task) to interpret utterances by inserting them into the plan the macro-structure (the global shape) of discourse.

a simplifying assumption. We make it because it enables us to avoid deciding (and implementing) how differing knowledge about actions get coordinated; dealing with such issues simply too difficult at present.

## 4 Negotiating with a dialogue system

In this section we present a worked out example of how the solutions of the planning problems introduced in the previous section can be used in order to perform internal bridging and trigger external bridging when appropriate.

In this example Frolog does not have enough knowledge yet in order to infer the bridge.<sup>2</sup> This is the case in instruction (37) in Figure 1. In this instruction the player wants Frolog to open the chest but Frolog does not know how to do this. In the screen-shot in the right you can see state of the interaction KB from turns (37) to (39). In this model we can see that the player does not have information about what fits into the chest, in order to unlock it. This is why the planner is not able to find a plan that achieves the precondition (`unlocked chest1`) of the command “open the chest” in instruction (37). The instruction in (39) fails as well making the obstacle explicit. Utterance (40) is an example of a CR caused by a required and unknown thematic relation filler (the second most frequent CR in the SCARE corpus).

Figure 1: *External* bridging in Frolog

Frolog's behavior continues as expected until turn (48) in which Frolog again is not able to bridge the command open the chest. It is to be expected that the fact that the golden key fits into

<sup>2</sup>For illustrations of other reasons that trigger negotiation of CIs see (Benotti, 2010).

the chest is mutual knowledge by now but Frolog is not reacting accordingly.

In order to overcome this issue there are two options: (1) either we allow different sources to update the mutual information losing uniformity in the update process or (2) we add actions that manipulate this kind of information. Here we describe option (1) that turns out to be the procedural version of “strict accommodation” (as defined in (Beaver and Geurts, in press)), and when generalized is of a piece with abduction (Hobbs, 1985). For an discussion of (2) we refer the reader to (Benotti, 2010).

We could say that the intuition behind the strict notion of accommodation is that when the speaker utters a sentence, she is not only trying to achieve the obvious effects of the utterance, but is also communicating the ways in which she assumes the world to be, and on which the success of the utterance depends. Following this intuition it can be argued that the intention behind the utterance “unlock the chest with the golden key” in turn (41) is twofold. It is clear that the player wants to achieve the effects of the action, that is, she wants to have the chest unlocked. But the player also expects Frolog to recognize the assumptions she is making and on which the success of the utterance depends. In particular, she expects Frolog to recognize that she is assuming that the golden key fits into the chest lock (this is why Frolog can coherently ask *why you do you think that the golden key will fit?*).

This means that, when an action is executed, the interaction KB will be updated not only with the effects of the action but also with its preconditions. And those preconditions that were not in the interaction KB before will be verbalized as in turn (9) in Figure 2.

Figure 2: *External* bridging becomes *internal*

The rest of the interaction (from turns (10) to (15)) show that once the proposition (`fitsin key1 chest1`) is added to the interaction KB the action “open the chest” can be internally bridged even when the chest is locked. Because the player and Frolog mutually know which key fits into the chest.

## 5 Discussion

Clearly, our inference framework is limited in many ways. But we think we’ve made a small step in the right direction. Dialogue systems are reaching a development level in which they cannot elude drawing inferences for much longer. This paper is a step in this direction.

Causal implicatures are a kind of relation implicature (historically Grice’s most obscure and crucial implicature) whose inference—we’ve argued—is essential in situated dialogue if our dialogue systems are not to violate the expectations of the user. Causal relations have a direct impact on the coherence structure of situated dialogues such as those in the SCARE corpus; in the SCARE corpus most pragmatic clarification requests make explicit causal implicatures.

We need to have a grasp on causal implicatures in order for our dialogue systems not only to decide what physical acts to do next—internal bridging—but also to generate causally-aware clarification requests—external bridging. Of course the inference framework presented here has many limitations that we discussed throughout the paper and probably classical planning is not the formalism that we will finally want to use in our dialogue systems (at least not in its present form). Our model is intended as a proof of concept, and intentionally stays at a level of formalization that is still simple enough so as not to lose our intuitions. The two intuitions that we don’t want to lose sight of are (1) utterances are to be interpreted *in a context* and need to be connected to this context (through some kind of relation, being causality one of the most important ones in situated dialogue) in order to be grounded (2) the process of connecting utterances to the context is a joint process, it is a negotiation that involves decisions of all the dialogue participants.

With the intuitions in place we plan to extend this work mainly by porting the inference framework into new domains.

There is lot to do yet, but we believe that the

negotiation of causal implicatures is a step towards an incremental dialogue manager.

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